2D array of far- infrared thermal detectors: noise measurements and processing issues

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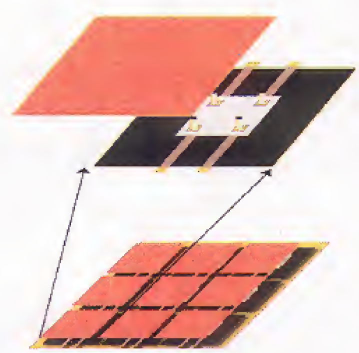
A magnesium diboride (MgB_2) detector 2D array for use in future space-based spectrometers is being developed at GSFC. Expected pixel sensitivities and comparison to current state-of-the-art infrared (IR) detectors will be discussed.
Key words: superconductor, thermal detectors, IR, signal-to-noise.

Introduction:

For high temperature superconducting (HTS) thin films to be used as the thermistor materials in an IR detector ease of process and noise performance are two important factors.

MgB_2 is a simple binary intermetallic compound with a superconducting transition at 39 K [1]. Compared to the cuprate HTSs, it has lower T_c and a very sharp transition of MgB_2. For the foreseeable future only moderately cooled focal planes (30-90K) are feasible on space missions because of stringent mass and power budgets. The lower operating temperatures are achievable using advanced cryo-cooling technology being developed both at NASA and elsewhere. One distinct advantage of growing high quality MgB_2 thin films on silicon substrates is the potential for fabricating single and 2D bolometer arrays using standard micro-electro-mechanical systems (MEMS) micromachining processes.

Fig 1: Conceptual layout of the 2-D array far-IR bolometer. Each pixel: 100 x100μm.



MgB2 thin film growth conditions and sample preparation have been discussed in an earlier publication [2]. The 2-D array processing and Spectral Noise Voltage Density Measurement (S_v) will be discussed.

Table 1 summarizes the properties of the MgB_2 thin film and compares the temperature noise K_n values, where

$$K_n = S_V (I_{bias} dR/dT)^{-1}$$

The lower the K_n value the better the S/N ratio when the film is used as a thermistor in a bolometer.

HTS	T_c (K)	dR/dT (K/T)	I_{bias} (mA)	S_V at 10 Hz ($nV/\sqrt{Hz}$)	K_n at 10 Hz (10^{-9} $K/\sqrt{Hz}$)
MgB_2	38.27	12.4	4	0.34	6.8
YBaCuO *	90	2.5	6.35	0.8	50
GBaCuO **	90.2	3414	50 $\times 10^{-3}$	21	123

Table 2. Properties of the MgB_2 , YBaCuO and GBaCuO.
The noise figures are at 10 Hz.
* HTS on sapphire [3,4], ** GdBCuO film on SiN [5]

The noise value and K_n clearly show that MgB_2 thin films, grown on SiN/Si substrates, can provide better S/N than current cuprate-based HTS bolometers.

The results presented will show that high quality MgB_2 thin film can be grown on low stress SiN on Si, Present work on low thermal capacity membranes with optimal thermal conductance being micro-machined/processed will be discussed.
The process optimization to create the 2-D array is under way and we anticipate the characterization of the pixels soon. This in turn will allow us to verify the S/N predictions made above.

Acknowledgments

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